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**Pacific
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Region**

Forest Pest Management

R6-89-02

**Forest Pest Survey of
Units 3, 5, 7, and 11,
Goldie Timber Sale,
Big Summit Ranger District,
Ochoco National Forest**

Forest Pest Survey of Units 3, 5, 7, and 11, Goldie Timber Sale, Big Summit Ranger District, Ochoco National Forest

By

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INTRODUCTION

During the week of November 14 to 16, 1988, the Forest Pest Management Pathology Group did a pest evaluation of four stands in the Goldie Springs area (T. 15 S., R. 20 E., secs. 22, 23, 24, 26, and 27). These stands had been tentatively identified by the District as having severe pest-caused damage. Purposes of the present evaluation were to determine amount and cause of damage and provide management alternatives to minimize future losses in the units.

METHODS

Stands were surveyed using a variable plot cruise technique. A Spiegel Relaskop was employed to define plots (BAF Standard = 40), and plots were located as shown for each stand in Figures 1 through 3. In the plots, the following information was recorded for all "in" trees: species, DBH, general condition (live, dead, standing, down) and, where appropriate, diseases or insects present. Two roots on opposite sides of all recently dead or symptomatic plot trees were excavated to a distance of 3 feet from the root collar and examined for evidence of stain, decay, or fungus mycelia. Roots and butts of old dead trees were dissected to determine character of wood decay. Trunks were examined for signs and symptoms of heart rot, and crowns were investigated for evidence of foliage disease and mistletoes. Bark was removed from stems of beetle-infested trees to expose galleries for species determination. From data collected in plots, stand tables were prepared for each unit.

STAND CONDITIONS

Results of the surveys showed that the stands did indeed have substantial amounts of pest damage. A stand-by-stand description is as follows:

Goldie 3 - This stand is composed of sapling, pole, and small saw-log sized white fir, ponderosa pine, Douglas-fir, western larch, and a few lodgepole pine. White fir is the most common species, but ponderosa pine is more abundant and well distributed in this stand than in other units surveyed. The stand has had several selective harvest entries and, overall, stocking is clumpy. Twenty-nine percent of all trees (containing 31% of the basal area) are dead. Most mortality involves white fir that have been killed by Armillaria root disease and associated fir engraver beetles. Armillaria root disease is distributed throughout the unit. Douglas-fir and larch dwarf mistletoes are also widely distributed in the stand and are associated with substantial amounts of Douglas-fir and western larch mortality. Many of the

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EXPERIMENT STATION

living white fir in the stand have been wounded and have a high potential for stem decay. Indian paint fungus conks were observed on 1 percent of the white firs, and projections from Flip, Aho, and Wiitala (Indian Paint Fungus: a method for recognizing and reducing hazard in advanced grand and white fir regeneration in eastern Oregon and Washington. 1983) indicate that 41 percent of the white firs may be infected. White fir and Douglas-fir were lightly to moderately defoliated by western spruce budworm in 1988. Table 1 summarizes tree numbers and basal area per acre by species, size, condition, and cause of pest damage in the Goldie 3 stand.

Goldie 5 - White fir is the major component of this stand, with lesser amounts of Douglas-fir, ponderosa pine, and western larch. The stand was selectively harvested in the past. It appears to be generally healthier than others evaluated in this survey, with the existing mortality more concentrated. Sixteen percent of the trees (containing 14 percent of the basal area) are dead. White fir killed by Armillaria root disease, annosus root disease, and fir engraver beetles account for a major part of the mortality. Most root disease occurs in the north center of the unit (see Figure 2). Some western larch have been killed by dwarf mistletoe. Larch dwarf mistletoe and Douglas-fir dwarf mistletoe are distributed throughout the stand. Heart rot, due to Indian paint fungus, is a concern on many living, wounded white fir in this stand. Twenty percent of the firs already exhibit conks of this fungus, and projections from Filip et. al. indicate that 44 percent of the firs may be infected. White and Douglas-firs were lightly defoliated by western spruce budworm in 1988. A few ponderosa pine around the margin of this stand have been infested by mountain pine beetle. Table 2 summarizes tree numbers and basal area per acre by species, size, condition, and cause of pest damage in the Goldie 5 stand.

Goldie 7 - This stand is dominated by white fir and Douglas-fir and has small components of western larch and ponderosa pine. It contains numerous very dense patches of sapling to small pole-sized white fir. Like other stands surveyed, it has a history of several past selective harvest entries. Seven percent of the trees (containing 19 percent of the basal area) are dead. Most of the mortality involves the larger white fir in the stand and is being caused by Armillaria root disease, annosus root disease, and fir engraver beetles. Root disease is distributed throughout the stand. Both Douglas-fir and western larch are heavily infected by their respective dwarf mistletoes, and larch dwarf mistletoe is associated with considerable mortality. The large proportion of white fir that are wounded in this stand indicates a high risk of stem decay. Six percent of the white fir exhibit conks of the Indian paint fungus, and projections from Filip et. al. suggest that 41 percent of the firs may be infected. White fir and Douglas-fir were lightly to moderately defoliated by western spruce budworm in 1988. Tree numbers and basal area per acre for the Goldie 7 stand are summarized by species, size, condition, and cause of pest damage in Table 3.

Goldie 11 - This stand is composed of white fir, ponderosa pine, and Douglas-fir. Most trees are pole-size or smaller. The stand has had past selective logging and exhibits particularly severe pest damage. Sixty-two percent of the trees (containing 59 percent of the basal area) are dead. Mortality is generally distributed and is due to Armillaria root disease and associated fir engravers on white fir and Armillaria root disease on Douglas-fir. There is also considerable Douglas-fir dwarf mistletoe in this

stand. The white and Douglas-firs were lightly to moderately defoliated by western spruce budworm in 1988. A few ponderosa pine exhibit brooming caused by Elytroderma needle cast. Table 4 summarizes tree numbers and basal area per acre by species, size, condition, and cause of pest damage in the Goldie 11 stand.

PESTS

Armillaria Root Disease - By far the most damaging root disease in the survey stands, Armillaria root disease is caused by the fungus Armillaria ostoyae. Not only is this disease responsible for considerable amounts of currently observable tree mortality, but plots with Armillaria root disease average only 60 percent as much basal area as plots without disease. A. ostoyae is the same fungal pathogen that has been known for years in the Pacific Northwest as A. mellea. Recent taxonomic work indicates that several species of Armillaria exist, and A. ostoyae is the species that infects northwest conifers.

A. ostoyae-infected trees can be identified by several characteristic signs and symptoms. Pole-sized and larger trees will display crown symptoms which usually include some, but not necessarily all, of the following: chlorotic foliage, shortened lateral and terminal leader growth, shortened needle length, reduced needle retention, overall thinning, and production of a distress cone crop. Small infected trees usually succumb rapidly, with crown symptoms appearing only a year or two prior to death. Often, small trees die with a full complement of foliage. Most infected trees exhibit copious basal resin flow (Figure 4). Diagnostic evidence of infection by A. ostoyae is the characteristic cream-colored mycelial fans which grow under the bark of the roots and butts of live-diseased or recently killed trees (Figure 5). Rhizomorphs, which appear as black, string-like structures with a white interior 2 to 4 mm across may sometimes be found on root surfaces of live-infected and recently killed trees, but are most common on trees that have been dead for 3 to 5 years. Since death is due to girdling caused by cambium killing at the roots and root collar, Armillaria-infected trees often die standing and topple later as roots decay. A. ostoyae-caused decay is characterized as a spongy, sometimes stringy, white to yellow rot. Characteristic thin black zone lines frequently occur throughout the decayed wood. Mushrooms of the fungus emerge from the soil around the base of live-infected and dead trees in the autumn. They are most abundant after significant rainfall. Mushrooms are honey-colored, with a stem 2 to 4 inches long, and a cap 2 to 3 inches across. The faint remnants of a ring may sometimes be seen on the upper portion of the stem.

A. ostoyae is a very efficient saprophyte that survives in stumps, roots, and other buried woody material. The fungus can infect living trees across root contacts or by growing short distances through the soil via rhizomorphs. Spread can be from roots of living or dead infected trees or stumps, and occurs at a rate of about 1 foot per year. Colonization of partially infected root systems occurs quickly after tree death. Root systems of large stumps or stubs which remain buried may contain viable A. ostoyae for up to 50 years. In plantations or stands that have had selective harvest, mortality frequently occurs first around old stumps.

Although A. ostoyae can be a weak pathogen that affects stressed or injured trees, in eastern Oregon it is often extremely virulent and causes dramatic losses in large progressively expanding centers that cover extensive areas (Figure 6). In such cases, the vigor of the host is not important in determining susceptibility to mortality. Susceptibility to damage does, however, vary greatly between tree species. In the Ochoco area, the species most susceptible to infection and mortality is white fir. Douglas-fir is somewhat less susceptible but can be damaged where there are heavy inoculum loads. Ponderosa pine and western larch are resistant to A. ostoyae.

Recommended control for Armillaria root disease is to harvest affected hosts and regenerate infection centers and 50-foot buffers around them with tree species that are resistant to the disease (pines or larch). Stock used to regenerate diseased areas should be of good vigor and be well adapted to the site.

Annosus Root Disease - Annosus root disease, caused by the fungus Heterobasidion annosum, is found in many parts of the world causing root and butt rot or mortality in conifers. However, white firs are the only species seriously affected by H. annosum in mixed conifer stands on the Ochoco National Forest.

Annosus root disease causes crown symptoms similar to those of Armillaria root disease, but symptoms frequently do not appear until just before the host dies. H. annosum causes a red-brown stain with uneven margins in the roots and root collars of live or recently dead infected firs (Figure 7). In old dead roots or stumps, a laminated decay with pitting on only one side of the sheets of wood is characteristic of H. annosum (Figure 8). The fungus produces fruiting bodies (Figure 9), but they are usually not encountered on recently killed firs. They are very common in the interiors of older stumps or snags, however, and these are usually found close to trees that are dying from the disease.

H. annosum is spread by windborne spores. Fruiting bodies produce large numbers of spores that are wind-carried for long distances. Spores that land on freshly-cut stump surfaces or recently-created wounds germinate and colonize woody tissues of the stump or tree. Subsequently, the fungus grow throughout the root system and spreads to nearby trees across root grafts or contacts. Centers of mortality develop as trees progressively become infected and die. Radial spread of centers is approximately 1 foot per year. Most infection centers are found around large (18 inches diameter or greater) white fir stumps that were cut at least 15 years previously.

Recommended control measures for annosus root disease are: (1) Favor tree species that are not susceptible to the disease (any species except white fir), or (2) where white fir management is desired, prevent stump infection by sprinkling borax on all large white fir stumps within 48 hours after they are cut.

Dwarf Mistletoes - The dwarf mistletoes are parasitic higher plants that are quite host-specific. In the survey area, Douglas-fir dwarf mistletoe (Arceuthobium douglasii) infects only Douglas-fir. Larch dwarf mistletoe (A. laricis infects western larch and, occasionally, lodgepole pine. Mistletoe spread is by forcibly discharged seeds that are shot out from mature female

plants and fall into the crowns of other trees below the host tree. Thus, conditions in multistoried stands, such as those in the Goldie Sale Area, are particularly favorable for dwarf mistletoe spread and buildup. On the average, Douglas-fir dwarf mistletoe seeds are shot out a distance of 10 feet and larch dwarf mistletoe seeds 20 feet. Once a mistletoe seed lands on susceptible host foliage, its sticky coating allows it to slide down to the twig and adhere at the base of a needle. The seed then germinates and produces an infection peg that grows into the host tissue. With time, the mistletoe plant develops both aerial shoots (Figures 10 and 11) and a sinker system (comparable to a root system) incorporated within the host. The dwarf mistletoe obtains food and water from the host and, at the same time, induces abnormal growth in the tree, resulting in swellings and witches'-brooms (Figures 12 and 13).

Douglas-fir and larch dwarf mistletoe are considered to be the most damaging diseases of their respective hosts. Obvious kinds of losses caused by the mistletoes include direct tree mortality and wood quality losses due to stem distortion, top-killing, and formation of large knots associated with witches'-brooms. In addition to mortality and wood quality losses, studies indicate that Douglas-fir and larch dwarf mistletoes also cause significant amounts of growth loss in infected stands. Growth loss is greatest in stands where a high percentage of trees are infected and large portions of tree crowns are occupied by witches'-brooms or infections occur high in the crowns. Infection levels being equal, growth loss is greater in intermediate-aged than young or old stands and in moderately-stocked rather than sparsely- or very heavily-stocked stands.

The fact that dwarf mistletoes are obligate parasites and rather specific to their hosts can be used in formulating control options. Control can be attained by converting infected stands to nonsusceptible tree species or by eliminating dwarf mistletoe, along with its hosts, in a regeneration harvest (clearcut, shelterwood, or seed tree cut). Following a clearcut, susceptible hosts can be reestablished on a formerly diseased site without danger of reinfection as long as the new stand is not contiguous to other mistletoe-infected stands. Following a shelterwood or seed tree cut, susceptible regeneration can be managed if the infected overwood is removed before new trees are 10 years old or 3 feet tall.

Stem Decay Fungi - Stem decay fungi, especially the Indian paint fungus (Echinodontium tinctorium) are causing losses in the white fir components of the Goldie Sale stands and have potential to cause much more as time goes by. True firs, as nonresinous, relatively thin-barked species are very susceptible to infection by decay pathogens and are prone to subsequent rapid decay development. Fungi involved in causing decay of white fir fall into two groups: wound colonizers and suppressed tree branchlet colonizers.

Wound colonizing fungi include Pholiota limonella, Haematostereum sanguinolentum, and a number of other fungi. These fungi infect hosts by means of windborne spores released from mushrooms or conks. Spores land on freshly created wounds, germinate, and colonize the wood behind the wound. Infection can occur through any kind of open wound. However, especially severe decay is associated with large wounds in contact with the soil.

The major suppressed tree branchlet colonizer is the Indian paint fungus. This fungus also spreads by windborne spores released from conks, but infection occurs through small (less than 2mm diameter) exposed branchlet stubs rather than through wounds. Most infection courts occur on understory trees that have been suppressed for at least 40 years. Once E. tinctorium has successfully colonized a branchlet stub and the stub is overgrown by the tree, the fungus enters a dormant state. Chlamydospores are formed that can survive for many years without causing decay. Dormant infections are activated to produce decay columns when wounds are created within 1 foot of the resting spores. Especially large decay columns develop when several dormant infections are activated at the same time. Losses caused by Indian paint fungus are greatest in severely wounded, released white-fir understories on north facing slopes.

Occurrence of stem decays can be detected by presence of conks (Figure 14) or mushrooms on affected trees, but such fruiting bodies often are not formed until many years after infection when decay is very advanced. Overmature white firs, firs that have been suppressed for many years, and firs with poor live crown ratios are more likely to have decay than young, vigorous firs. Also, true firs with wounds have a particularly high probability of being infected and containing advanced decay.

Douglas-firs, pines, and larch are quite resistant to decay and are much less likely to suffer significant losses than are true firs. Favoring the more decay-resistant tree species is an excellent way to limit stem decay losses. Management of unthrifty, suppressed white fir understories and maintenance of older fir stands with many wounded trees, resulting from lack of care during harvest entries, should be avoided at all cost. Where white fir is a desired species for management, tree vigor should be promoted, wounding should be prevented, and rotations should be kept to less than 120 years.

Elytroderma Needle Cast - Elytroderma needle cast, caused by the fungus Elytroderma deformans, can be common on ponderosa pine on moist sites, at the edge of meadows, and along creek drainages in the Ochoco National Forest. It occurs in the survey area but does not appear to be damaging.

Elytroderma needle cast can be recognized by the conspicuous branch flagging it causes in spring, the compact up-turned witches'-brooms it induces (Figure 15), and by black, elongated fruiting bodies on infected needles in summer.

The disease is spread by windblown spores that are produced during the summer months. Moist conditions favor infection, and only current year's foliage is infected. Symptoms appear the year after, and since the fungus becomes systemic, remain for many years.

No special control is necessary for this disease in the survey area, but selective removal of infected trees during harvest may be warranted in areas where the disease is more severe. A concern with Elytroderma needle cast is its resemblance to western dwarf mistletoe (Figure 16), a much more serious disease with significant management implications. Ponderosa pine dwarf mistletoe was not encountered in the survey stands but is very common in many areas on the Ochoco National Forest.

Western Spruce Budworm - The western spruce budworm (Christoneura occidentalis) is a major defoliator of Douglas-fir and white fir on the Ochoco National Forest. The budworm completes one generation a year throughout most of its range. In Oregon and Washington, adults, which are mottled gray to orange-brown moths about 1/2-inch long, fly in late July or early August, mate, and lay eggs on the underside of needles. After eggs hatch, the larvae seek overwintering sites on limbs, boles, under bark scales, or in other protected places. Here they overwinter within silken sheaths (hibernacula). Larvae have black heads and are a cinnamon color in early instars, later turning an olive-green color with black blotches and reddish to tan-colored heads. In early May, larvae become active and bore into old needles and developing buds to feed. Larvae leave the year-old needles for new foliage when it flushes, webbing together needles to form a shelter as they feed. By early July, the damaged needles turn reddish brown and become visible from a distance (Figure 17). Repeated years of feeding significantly reduces the amount of host foliage and also affects seed production since staminate flowers and conelets are fed upon as well as foliage. Larvae usually complete development in July, transform into pupae, and emerge as adults about 10 days later. Budworm outbreaks (typically lasting from 6 to 10 years) may result in growth loss, top-kill, deformity, and sometimes mortality, especially of understory host trees.

Certain site and stand conditions favor budworm and enhance associated damage. These include large expanses of stands with major components of hosts, all-aged stands with multilayered canopies composed primarily of hosts, and host stands growing on warm, dry sites. Recommended management of western spruce budworm involves favoring non-hosts (pines and western larch) in individual stands or suppressing high populations of budworm over large areas with chemical or biological insecticides.

Fir Engraver Beetles - Fir engraver beetles (Scolytus ventralis) are commonly associated with mortality of white fir on the Ochoco National Forest. The adults are shiny black, 1/8-inch long, squat beetles with a pronounced ventral declavity. They fly in summer and infest trees that usually are under some degree of stress. They show a marked preference for root disease-affected trees, but also can infest wounded or drought-damaged firs. Sometimes, they will "strip attack" a tree, killing cambium on only a portion of the stem or in just the top of the tree.

Adults bore into trees and produce a deeply scored horizontal gallery slightly bowed at the end and containing a central nuptual chamber. Eggs are laid in notches along this gallery and the larvae, when they hatch, mine up and down the stem from the adult gallery. Knowing the characteristic gallery pattern (Figure 18) is the best identification tool for this insect. Crowns of infested trees fade rapidly the year after they are attacked.

Since fir engravers mainly infest weakened trees, the best management strategy is to attempt to address the cause of tree stress. In the survey area, controlling root disease will also control fir engravers.

Mountain Pine Beetle - Mountain pine beetles (Dendroctonus ponderosae) are the major insect enemies of pole to small saw timber-sized ponderosa pine throughout eastern Oregon. Adults are stout, black, cylindrical beetles 1/8- to 1/5-inch long. Since they overwinter in all stages of development, mountain

pine beetle broods emerge at several times during the summer. Adults may be flying from June to September.

Adult galleries are bored in the host phloem parallel with the grain and are packed with frass. Larval galleries extend at right angles to the parent gallery (Figure 19). Attacked trees usually exhibit pitch tubes. Blue stain (caused by fungi) is associated with the galleries. Crowns of infested trees fade rapidly the year after attack and develop a straw color.

Mortality caused by mountain pine beetles in ponderosa pine is almost always associated with overstocking. Infestation usually occurs in stands with basal areas in excess of 150 square feet per acre. Management is best attained through stocking control. Thinning or harvesting stands before outbreaks occur is the best approach to management.

SPECIFIC MANGEMENT RECOMMENDATIONS FOR THE GOLDIE STANDS

(1) In the Goldie 3, 7, and 11 stands, the existing white fir and Douglas-fir components should not be retained due to their severe pest problems. Much of the larch is also poor risk for management. We recommend that two options be considered for treatment of these units: (A) clearcut the existing stands and replant the sites with local seed source ponderosa pine or a ponderosa pine/lodgepole pine/western larch mixture, or (B) do seed tree cuts, retaining ponderosa pine or ponderosa pine and the best western larch as seed trees. If any dwarf mistletoe-infected larch have to be retained as seed trees, remove them before the new larch regeneration is 10 years old or 3 feet tall. New stands developed on these sites resulting from use of either option should receive thinnings to keep basal areas below 150 square feet per acre throughout the rotation.

(2) The Goldie 5 stand could also be treated as described above. However, the existing stand on this unit is a better risk for management than the others surveyed. If it is deemed desirable to retain and manage the existing stand, it should be thinned, favoring in order as leave trees: (A) ponderosa pine, (B) western larch with no dwarf mistletoe infections, (C) Douglas-fir with no dwarf mistletoe infections, (D) western larch with light dwarf mistletoe infections in the bottom halves of their crowns, and (E) unwounded, vigorous white fir with good live crown ratios. No white fir, regardless of crown condition or wounding history, should be retained in the Armillaria root disease-affected area in the north center of the unit (see Figure 2). Dwarf mistletoe-infected Douglas-fir should also be discriminated against. Stocking should be maintained below 150 square feet of basal area per acre throughout the remainder of the rotation. At the time of final harvest, a prescription should be developed that will feature pine and larch in the subsequent rotation.

Table 1

Mean number of trees per acre and square foot basal area (in parenthesis) for the Goldie 3 Unit

Diameter Class	White Fir		Douglas-fir			Western Larch	Ponderosa Pine
	Live	Dead	Live		Dead	Dead	Live
	Healthy	Ao 1	Healthy	Dm 2	Dm 2	Dm 2	Healthy
6	12.0 (2.3)	12.0 (2.3)		12.0(2.3)			
8	6.7 (2.3)	6.7 (2.3)					6.7 (2.3)
10	8.6 (4.7)	8.6 (4.7)	4.3(2.3)				
12	15.0(11.8)	6.0 (4.7)			3.0(2.3)	3.0(2.3)	12.0 (9.4)
14			2.2(2.3)				
16	3.4 (4.7)						
18	1.3 (2.3)						1.3 (2.3)
20						1.1(2.3)	1.1 (2.3)
22	0.9 (2.3)						
24							
26							
28							
30							
32							0.4 (2.3)
34							
36							
38							
40							
42							
44		0.2 (2.3)					0.2 (2.3)
Total	47.9(30.4)	33.5(16.3)	6.5(4.6)	12.0(2.3)	3.0(2.3)	4.1(4.6)	21.7(20.9)

1/ Ao = Armillaria ostoyae-infected 2/ Dm = Dwarf mistletoe infected

Table 2: Mean number of tree per acre and square foot basal area (in parenthesis) for the Goldie 5 Unit

Diameter Class	White Fir			Douglas-fir		Western Larch		Ponderosa Pine
	Live	Dead		Live		Live	Dead	Live
	Healthy	Ha 1	Ao 2	Healthy	Dm 3	Dm 3	Dm 3	Healthy
6								
8	15.3 (5.3)							
10	24.5(13.3)		9.8 (5.3)		4.9 (2.7)			
12	13.6(10.7)							
14	10.0(10.7)		5.0 (5.3)					2.5 (2.7)
16	5.7 (8.0		1.9 (2.7)		1.9 (2.7)	1.9(2.7)		
18	3.0 (5.3)			1.5(2.7)			1.5(2.7)	1.5 (2.7)
20	1.2 (2.7)							
22	3.0 (8.0)	1.0(2.7)			1.0 (2.7)			1.0 (2.7)
24	0.8 (2.7)				1.7 (5.3)			
26	0.7 (2.7)							
28								0.5 (2.7)
30	0.5 (2.7)							
32	1.4 (8.0)							
34								
36								
38	0.3 (2.7)							0.3 (2.7)
40								
42								
44								
46								
48								
50								
52	0.2 (2.7)							
Total	80.2(85.5)	1.0(2.7)	16.7(13.3)	1.5(2.7)	9.5(13.4)	1.9(2.7)	1.5(2.7)	5.8(13.5)

1/ Ha = Heterobasidion annosum-infected 2/ Ao = Armillaria ostoyae-infected 3/ Dm = dwarf mistletoe-infected

Table 3: Mean number of tree per acre and square foot basal area (in parenthesis) for the Goldie 7 Unit

Diameter Class	White Fir			Douglas-fir		Western Larch		Ponderosa Pine
	Live	Dead		Live		Live	Dead	Live
	Healthy	Ha 1	Ao 2	Healthy	Dm 3	Dm 3	Dm 3	Healthy
6	34.0 (6.7)							
8	57.3(20.0)							
10	36.7(20.0)			18.3(10.0)			6.1(3.3)	
12	21.2(16.7)					4.2(3.3)		4.2(3.3)
14	12.5(13.3)		3.1 (3.3)	3.1 (3.3)	6.2 (6.2)		3.1(3.3)	3.1(3.3)
16	11.9(16.7)			2.4 (3.3)	2.4 (3.3)			
18	1.9 (3.3)	1.9(3.3)			1.9 (3.3)	1.9(3.3)		
20					1.5 (3.3)			
22		1.3(3.3)						
24		1.1(3.3)	1.3 (3.3)					
26								
28			0.8 (3.3)					
30								
32			0.6 (3.3)					
34								
36								
38			0.4 (3.3)					
Total	175.5(96.7)	4.3(9.9)	6.0(16.3)	23.8(16.6)	12.0(16.1)	6.1(6.6)	9.2(6.6)	7.3(6.6)

1/ Ha = Heterobasidion annosum-infected 2/ Ao = Armillaria ostoyae-infected 3/ Dm = dwarf mistletoe-infected

Table 4: Mean number of tree per acre and square foot basal area (in parenthesis) for the Goldie 11 Unit

Diameter Class	White Fir		Douglas-fir		Ponderosa Pine
	Live	Dead	Live	Dead	Live
	Healthy	Ao 1	Healthy	Ao 1	Healthy
6					
8	38.2(13.3)	38.2(13.3)		38.2(13.3)	
10	24.5(13.3)				
12		17.0(13.3)			
14	12.5(13.3)	25.0(26.7)			
16			9.5(13.3)	9.5(13.3)	
18					
20					6.1(13.3)
22					
24		4.2(13.3)			4.2(13.3)
Total	75.7(39.9)	84.4(66.6)	9.5(13.3)	47.7(26.6)	10.3(26.6)

1/ Ao = Armillaria ostoyae-infected

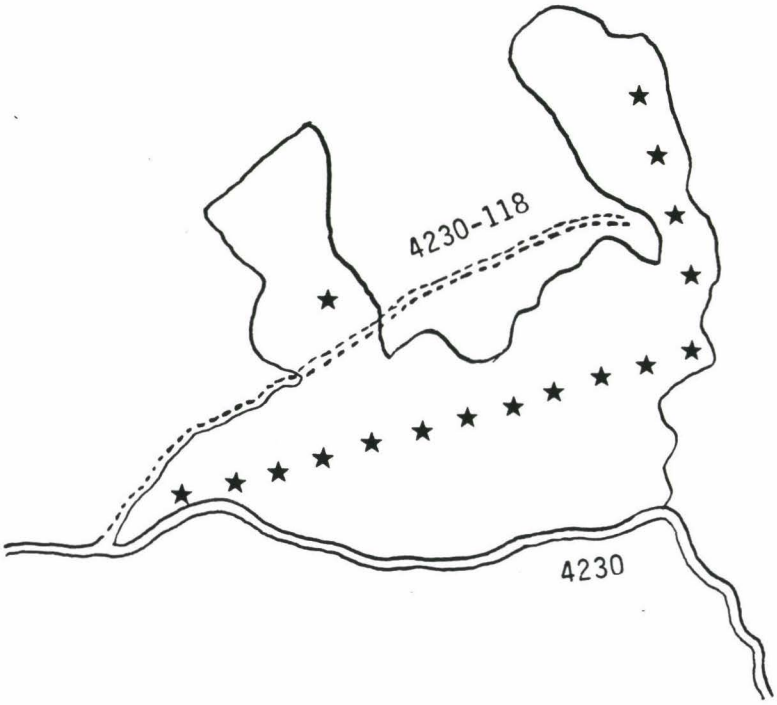

Fig. 1: Map of Goldie Unit 3 showing location of plots used in forest pest survey.

Fig. 2: Map of Goldie Unit 5 showing location of plots used in forest pest survey. Hatched area has severe Armillaria root disease.

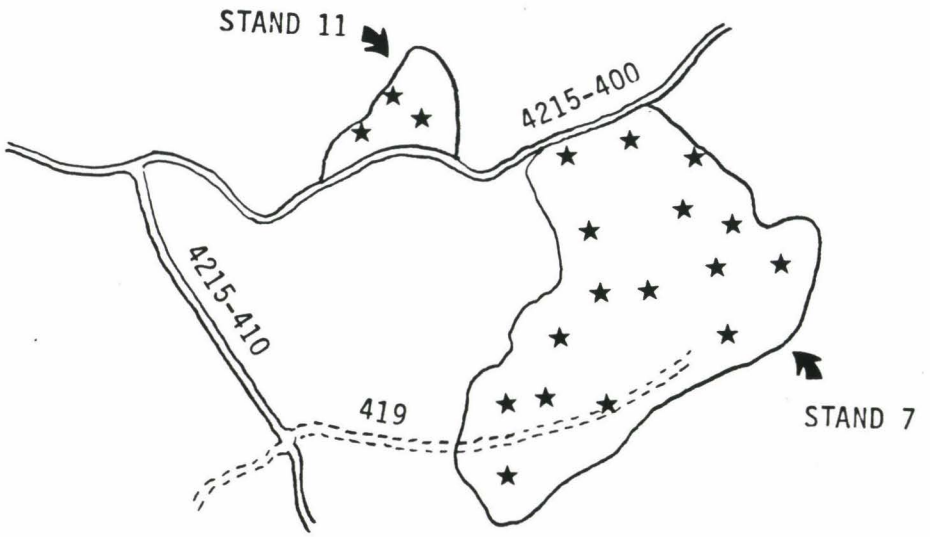

Fig. 3: Map of Goldie Units 7 and 11 showing locations of plots used in forest pest survey.

Fig. 4: Heavy basal resin flow on Douglas-fir affected by Armillaria root disease.

Fig. 5: Typical cream-colored mycelial fan of Armillaria ostoyae under bark of infected white fir.

Fig. 6: Large Armillaria root disease center. Note down, standing dead, and declining white fir in pocket. Resistant ponderosa pine are not being affected.

Fig. 7: Reddish brown stain with uneven margin in root of Heterobasidion annosum-infected white fir.

Fig. 8: Typical decay caused by H. annosum in white fir. Decay is laminated with pitting on only one side of the wood sheets.

Fig. 9: Fruiting bodies (conks) of H. annosum in hollow white fir stump. Note dark upper surface and bluff to cream colored pore layer beneath.

Fig. 10: Douglas-fir dwarf mistletoe plants on infected branch. Note small size (1/4- to 1/2-inch long) and olive-green color.

Fig. 11: Larch dwarf mistletoe plants on infected western larch branch. Note larger size 1-1/2 to 4 inches long), purple to olive color, and association with spindle-shape swelling.

Fig. 12: Witches'-brooms caused by Douglas-fir dwarf mistletoe. Note large size and clumped appearance.

Fig. 13: Witches'-brooms caused by larch dwarf mistletoe. Note smaller size and frequent occurrence close to bole. Also note stem burls where old infected branches have broken off.

Fig. 14: Indian paint fungus conk on white fir. Conk is hoof-shaped with rough, dark upper surface and grey, coarse teeth on the under surface. Interior is bright orange. Presence of conk indicates considerable cull.

Fig. 15: Witches'-broom on ponderosa pine caused by Elytroderma needle blight. Note that broom is compact with upward turning branch tips. Reddened needles are typical in spring.

Fig. 16: Ponderosa pine branch infected by western dwarf mistletoe. Note numerous rather large shoots (3 to 8 inches long) and more open character of associated witches'-broom.

Fig. 17: Feeding damage caused by western spruce budworm.

Fig. 18: Typical gallery pattern of fir engraver beetle under bark of white fir.

Fig. 19: Typical gallery pattern of mountain pine beetle. Also note associated blue stain.